TOOL FOR FORMING PRECISELY CURVED SURFACES

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and tool for forming precisely curved surfaces, in particular, useful for reflectors of electromagnetic radiation and microwave antennas.

2. Description of the Prior Art

Such reflectors and antennas conventionally are produced in a tedious and costly manner. For example, fabrication of a reflector having a parabolic surface, such as is used in reflector telescope mirrors, requires time-consuming optical polishing of glass or ceramic substrates and subsequent metallizing, and include refined grinding and polishing techniques. Alternate techniques, like centrifugal casting on a rotating turntable, contour turning on a tracer lathe, and plastic injection molding in optical precision molds, have been successfully employed in the past. These manufacturing techniques involve high costs as a result of high labor content and/or expensive tooling. In a like manner, other reflectors are produced by costly electro-forming or precision casting techniques.

Further techniques for shaping articles may be classified among that art relating to stretch and die forming of metal stock, as typified by U.S. Pat. No. 2,961,028, and that to plastic reinforced reflectors and antennas as shown in U.S. Pat. Nos. 3,337,660; 3,374,482; 3,658,971 and 3,897,294. U.S. Pat. No. 2,961,028 preconditions stock by stretching it above its elastic limit to render it more flowable and plastic before being work-hardened as it is formed between matching surfaces of drawing dies. In U.S. Pat. No. 3,337,660 a thin circular diaphragm or membrane which is clamped around its periphery, is stretched beyond its elastic limit by differential pressure, after which a solidifiable substance, such as an epoxy resin or a polyurethane foam, is poured onto and hardened on the diaphragm. U.S. Pat. No. 3,374,482 molds a foamed-in plastic onto a preformed metallized reflective surface. U.S. Pat. No. 3,658,971 describes a process wherein a foamable composition is injected within a cavity closed by an adhesived strip. Knife edges about the mold peripheries of the cavity sever the adhesived strip upon completion of the expansion of the foamable material, to enable removal of the molded article. U.S. Pat. No. 3,897,294 describes an involved method of forming a parabolic antenna reflector provided with machined slots and holes for receipt of a waveguide feedhorn, and mounting structure for a hyperbolic surface. The parabolic reflector is formed, in part, from a flat copper or copper plastic sheet which is subjected to pressure exerted by a specially prepared paraboloid and mold ring.

These prior art devices are incapable of producing precision reflectors and antennas in that the stretching forces exerted on the materials are anisotropic, i.e., not extending equally in all directions across the surface of the material, which result in astigmatism of the deformed surface. Freeblown shapes also suffer from large aberrations and uncontrolled focal length.

SUMMARY OF THE INVENTION

The present invention avoids or overcomes the above-problems or shortcomings of the prior art by sequential isotropic planar stretching and stretch forming of a blank or membrane. The curvature is obtained by hydraulic or pneumatic stretch forming either without constraints or over a precision mandrel template. Thereafter, the blank is capable of being structurally supported. Where needed, precise perforations are incorporated in the formed blank.

It is, therefore, an object of the present invention to provide a process and tool for producing precisely curved, lightweight, low-cost reflectors and antennas.

Another object is to provide for such a process and tool which avoids the introduction of deformations resulting from anisotropically exerted forces on the reflector or antenna surface.

Another object of the present invention is to provide for such a process and tool which is capable of imparting any desired contour to such a surface.

Other aims and objects as well as a more complete understanding of the present invention will appear from the following explanation of exemplary embodiments and the accompanying drawings thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a tool for forming freeblown curved axicon surfaces;

FIG. **2** is an enlarged view of a section of the membrane or diaphragm of FIG. **1**;

FIGS. **3** and **4** depict means for clamping and isotropically stretching the membrane;

FIG. **5** is a view of the reflective side of the surface shown in FIG. **1** when perfectly flat;

FIGS. **6–10** illustrate various configurations of the membrane depending the exertion of positive or negative forces thereon in conjunction with a central adjustable mechanical point support; and

FIGS. **11–15** depict a series of steps whereby a permanently deformable blank may be contoured to form a precision curved surface supported by backing structure.

DETAILED DESCRIPTION OF THE INVENTION

The principal surfaces which can be generated by use of the structure shown in FIGS. **1–10** have the shape of a spheroid and a spheroidal axicon. As defined herein, a spheroid is the surface described by the rotation of a sphere about its axis. An axicon is an optical element with a pyramidal surface of revolution. When inserted into a collimated beam of light, the axicon forms a beam in the form of a hollow cone. An axicon lens consists of a body with one surface which is flat and the opposite surface which is conical, not spherical.

Accordingly in FIG. **1**, a tool **20** includes a holder comprising a clamping ring flange **24** and a clamp base flange **26** secured together by any suitable attachment, such as nuts and bolts **28** equally spaced about the periphery of the holder. Clamping ring **24** and clamp base **26** respectively have clamping surfaces **30** and **32** which, when pressed by attachments **28** securely hold a deformable diaphragm **34** therebetween. To be reflective, the diaphragm may comprise, for example as shown in FIG. **2**, an elastic polyester film **36** having an aluminized surface **38** thereon, or a plastically deformable copper sheet. Alternatively, the diaphragm may be